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Chapter 2. Agricultural Water Use Efficiency

The Agricultural Water Use Efficiency Strategy describes the use and application of scientific processes to control agricultural water delivery and use to achieve a beneficial outcome. It includes, 1) an estimation of net water savings resulting from implementation of efficiency measures as expressed by the ratio of output to input; 2) resulting benefits; and 3) strategies to achieve efficiency and benefits.

Water conservation is defined by the CWC Section10817 as “the efficient management of water resources for beneficial uses, preventing waste, or accomplishing additional benefits with the same amount of water.” The estimation of net water savings is the reduction in the amount of water applied that becomes available for other purposes, while maintaining or improving crop yield and agricultural productivity. Net water savings (discussed in Box 2-1) recognizes 1) uptake and transpiration of water for crop water use, 2) the role, benefits, and quantity of applied water that is recoverable and reusable in the agricultural setting, and 3) the quantity of irrecoverable applied water that flows to salt sinks, such as the ocean and inaccessible or degraded saline aquifers, or evaporates to the atmosphere, and is unavailable for reuse. The benefits, in addition to water savings, may include water quality improvements, environmental benefits, improved flow and timing, and often increased energy efficiency.

PLACEHOLDER Box 2-1 Net Water Savings and Applied Water Reduction

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

The strategy to achieve agricultural water savings and benefits primarily includes improvements in technology and management of water at various special scales including on-farm, at the irrigation district level, and at a regional scale. The strategy may be dependent on an array of factors such as labor, market, demographics, changes in government policies, funding availability, environmental stresses, desire to increase yield, education, energy, water supply development, water delivery systems, legal issues, economics, and land use issues.

A list of best management practices (other than irrigation technology and management of water) that contribute to agricultural water use efficiency are included in Chapter 20, Agricultural Lands Stewardship. This narrative presents the costs and benefits of efficiency improvements in on-farm irrigation equipment, crop and farm water management, and water supply management and distribution systems.

Agricultural Water Use Efficiency Efforts in California

Agriculture is an important element of California’s economy. According to the 2011-12 report of the California Department of Food and Agriculture, the state’s 81,700 farms and ranches received $37.5 billion for their output in 2010, 1% higher than the previous record set in 2008. California remained the No. 1 state in cash farm receipts in 2010, with its $35.7 billion in revenue representing 11.9 percent of the U.S. total. The state accounted for 16 percent of national receipts for crops, and 7 percent of the U.S. revenue for livestock and livestock products. California’s agricultural abundance includes more than 400 commodities. The state produces nearly half of U.S.-grown fruits, nuts and vegetables. California's agricultural exports broke a record in 2010 with $14.7 billion in value. It is estimated that every $1 billion in agricultural exports supports 8,400 jobs. The Department of Water Resources (DWR) estimated 2010 irrigated acreage was 8.13 million acres, excluding double cropping. The irrigated acreage changes from year-to-year. Agricultural water application varies significantly by year, depending on drought conditions. In a typical year, agriculture will irrigate about 9.6 million acres with 34 million acre-feet of water, or about a third of available surface water supplies.

In California, growers and water suppliers implement state-of-the-art design, delivery, and management practices to increase production efficiency and conserve water. As a result, they continue to make great strides in increasing the economic value and efficiency of their water use. Among the indicators of agricultural water use efficiency improvement is that the real inflation-adjusted gross revenue for California agriculture increased about 88 percent between 1967 and 2010, from $19.9 billion (in 2007 dollars) to $37.5 billion. During that period the total California crop applied water use fell by 20 percent, from 31.2 million acre-feet, to a baseline of 24.9 million acre-feet. As a result, the "economic efficiency" of agricultural water use in California has more than doubled in the same period, from $638/AF (2007 dollars) in 1967 to $1,506/AF in 2010, where most of the increase has occurred since 2000. Between 2000 and 2010 real gross agricultural revenue per acre-foot of applied water increased about 43.7 percent, from $1,048/AF to $1,506/AF.

It is important however to note that the economic output of California agriculture, expressed either in terms of crop yield or the dollar value of produced crops, is a function of a multitude of variables to include: water quality, soil fertility, fertilizer applications, insect infestation, plant diseases, cultural practices, management, crop selection, crop variety, as well as many other physical, biological, and socio-economic factors including crop market, trade and market conditions, and weather conditions. Given the complex factors affecting agricultural productivity, any economic output indicator can only be used as an overall gauge of the efficiency and competitiveness of California's agriculture and its agribusiness establishment in general and can in no mean be exclusively linked to the efficiency of water use.

The Agricultural Water Suppliers Efficient Water Management Practices Act of 1990 (AB 3616) and the federal Central Valley Project Improvement Act of 1992 (CVPIA) established guidance for improving agricultural water use efficiency. As of July 2009, the Agricultural Water Management Council (AWMC), through a Memorandum of Understanding (MOU), united 79 agricultural water suppliers and four environmental organizations in an effort to improve water use efficiency through implementation of efficient water management practices (AWMC, 1999). AWMC recognizes and tracks water supplier water management planning and implementation of cost-effective efficient water management practices through a review and endorsement procedure. The signatory agricultural water suppliers voluntarily commit to implement locally cost-effective management practices. Agricultural water supplier signatories represent more than 4.6 million acres of retail irrigated acreage and a total of 5.86 million acres of agricultural land. Sixty-six signatories to the MOU have submitted water management plans, six signatories are not subject to development and submittal of Water Management (WM) Plans, and the remaining seven signatories are in the process of development and submittal of their WM Plans. All submitted WM Plans have council-endorsed plans.

As part of a comprehensive package of water legislation in the 2009-2010 legislative session, the Agricultural Water Management Planning Act in SB X7-7 requires agricultural water suppliers who provide water to 10,000 or more irrigated acres to develop and adopt a water management plan with specified components, and implement cost-effective Efficient Water Management Practices (EWMPs). But any agricultural water supplier that provides water to less than 25,000 irrigated acres shall not implement the requirement of the bill unless sufficient funding has been provided to that water supplier to implement its provisions.

The bill's requirements also include:

- Agricultural water suppliers are required to submit their water management plan to DWR.
- Agricultural water suppliers are required, on or before July 31, 2012, to implement EWMPs including the following critical EWMPs: 1) Measure the volume of water delivered to customers with sufficient accuracy to comply with provisions of the bill, and 2) Adopt a pricing structure for water customers based on at least in part on quantity of water delivered.
- Agricultural water suppliers are required to use a standardized form to report which EWMPs have been implemented and are planned to be implemented, an estimate of water use efficiency improvements that have occurred since the last report, and an estimate of water use efficiency improvements estimated to occur five and 10 years in the future. If an agricultural water supplier determines that an EWMP is not locally cost effective or technically feasible, the supplier shall submit information documenting that determination.
- DWR is required, in consultation with the State Water Resources Control Board (State Water Board), the California Bay-Delta Authority (CBDA) or its successor agency, the State Department of Public Health, and the Public Utilities Commission, to develop a single standardized water use reporting form to meet the water use information needs of each agency.
- DWR is required, in consultation with the State Water Board, to submit to the Legislature a report on the agricultural EWMPs that have been implemented and are planned to be implemented and an assessment of the manner in which the implementation of those EWMPs has affected and will affect agricultural operations, including estimated water use efficiency improvements.
- DWR is required to make available all submitted water management plans on DWR's web site.
- DWR is also required, in consultation with the AWMC, academic experts, and other stakeholders, to develop a methodology for quantifying the efficiency of agricultural water use. Alternatives to be assessed, shall include, but not be limited to, determination of efficiency levels based on crop types or irrigation system distribution uniformity.
- As noted, SBx7-7 requires implementation of specific EWMPs for agricultural water use (see Box 2-2). Two of the EWMPs were deemed as critical for agricultural water suppliers to implement them: (1) measuring the volume of water delivered to customers with sufficient accuracy (the subject of this regulation), and (2) adopting a pricing structure for water customers based at least in part on quantity delivered.

PLACEHOLDER Box 2-2 Agricultural Efficient Water Management Practices (EWMPs)

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

The SB X7-7 requirements do not however apply to an agricultural water supplier that is a party to the Quantification Settlement Agreement, as defined in subdivision (a) of Section 1 of Chapter 617 of the Statutes of 2002, during the period within which the Quantification Settlement Agreement remains in effect. After the expiration of the Quantification Settlement Agreement, to the extent conservation water projects implemented as part of the Quantification Settlement Agreement remain in effect, the conserved water created as part of those projects shall be credited against the obligations of the agricultural water supplier pursuant to SB X7-7.

Box 2-3 give a listing of SB X7-7 mandates related to agricultural water use efficiency in which DWR is identified as the lead agency.

PLACEHOLDER Box 2-3 SB X7-7 Agricultural Water Use Efficiency DWR Mandates

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

Agricultural Water Measurement

Lack of data, mainly farm-gate irrigation water delivery data, is an obstacle for assessing irrigation efficiencies and planning further improvement. The State lacks comprehensive statewide data on cropped area under various methods of irrigation, applied water, crop water use, irrigation efficiency, water savings, and the cost of irrigation improvements per unit of saved water. Collection, management and dissemination of data to growers, water suppliers, and water resource planners are necessary for promoting increased water use efficiency. A concern identified by some members of the California Water Plan Advisory Committee is a lack of statewide guidance to assist regions and water suppliers to collect the data needed for future Water Plan updates in a usable format.

The 2003 Independent Panel on the Appropriate Measurement of Agricultural Water Use convened by CBDA made specific recommendations for measurement of water supplier diversions, net groundwater use, crop water consumption, and aggregate farm gate deliveries (Independent Panel, 2003). In addition, the panel recommended increased efforts to measure water quality, return flows, and streamflow. As a result, AB 1404 (Water Measurement Information) was signed into the California Water Code, requiring agricultural water suppliers to submit water use measurement reports to DWR. Agricultural water suppliers supplying 2000 or more acre-feet of surface water annually for agricultural uses or serving 2000 or more acres of agricultural lands are required to submit the report. The law requires these suppliers to submit annually a report that includes aggregated farm-gate delivery data on a monthly or bimonthly basis. Farm-gate delivery data is the volume of water delivered from the supplier’s distribution system to its customers, measured at the point where the water is delivered.

With the passage of the SB X7-7 (2009) legislation, certain agricultural water suppliers are required to measure the water they deliver to their customers. The legislation also required DWR to adopt regulation that provides a range of water measurement options that would allow agricultural water suppliers to implement the aforementioned critical EWMPs (measurement and volumetric pricing) and comply with the reporting of aggregate farm-gate water deliveries.

Subsequently, DWR convened an agricultural stakeholders committee (ASC) and a stakeholders’ sub-committee focusing on water measurement. Based on input from the ASC, stakeholders, and the general public, DWR adopted an emergency agricultural water measurement regulation that went into effect on July 2011. DWR followed by filing for a permanent regulation through a regular rulemaking process. On July 2012, the California Office of Administrative Law approved the permanent Agricultural Water Measurement Regulation. The Regulation adds Sections 597 to 597.4 of the California Code of Regulations (CCR) Title 23, Division 2, Chapter 5.1. The process leading to the development and adoption of the Regulation gained from the participation and input of various stakeholders, academic experts, and the general public. The process included several meetings of the ASC and its water measurement sub-committee, two public hearings, two listening sessions, a 45-day comment period, and six 15-day comment periods.

Agricultural Water Management Planning

SBX7-7 Part 2.8 (known as the Agriculture Water Management Planning Act) requires that agricultural water suppliers meeting certain criteria must prepare an Agricultural Water Management Plan (AWMP). This act provided a list of required elements that must be included in the AWMP (see Box 2-4). CWC Section10820 (a) states: “An Agricultural water supplier shall prepare and adopt an agricultural water management plan in the manner set forth in this chapter on or before December 31, 2012, and shall update that plan on December 31, 2015, and on or before December 31 every five years thereafter.” Where an ‘Agricultural Water Supplier’ is defined as “Agricultural water supplier” is defined as a water supplier, either publicly or privately owned, providing water to 10,000 or more irrigated acres, excluding recycled water. “Agricultural water supplier” includes a supplier or contractor for water, regardless of the basis of right that distributes or sells water for ultimate resale to customers.” (CWC Section10608.12)

PLACEHOLDER Box 2-4 Required Elements of an Agricultural Water Management Plan (AWMP)

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

CWC Section10842 requires an agricultural water supplier to implement its adopted plan in accordance with the schedule set forth in the plan, as determined by the governing body of the agricultural water supplier. An agricultural water supplier is also required to submit a copy of its plan and amendments or changes to the plan to each of the following entities: (1) DWR; (2) Any city, county, or city and county within which the agricultural water supplier provides water supplies; (3) Any groundwater management entity within which jurisdiction the agricultural water supplier extracts or provides water supplies; (4) Any urban water supplier within which jurisdiction the agricultural water supplier provides water supplies; (5) Any city or county library within which jurisdiction the agricultural water supplier provides water supplies; (6) The California State Library; and (7) Any local agency formation commission serving a county within which the agricultural water supplier provides water supplies.

Affected by the Agricultural Water Management Planning Act are agricultural water suppliers providing water to equal or greater than 25,000 irrigated acres (and water supplier providing 10,000 to 25,000 acres if adequate funding is available), excluding recycled water. Agricultural water suppliers that submit water management plans in compliance with the AWMC MOU requirements or the USBR Central Valley Project Improvement Act (CVPIA) or the Reclamation Reform Act of 1982 (RRA) requirements may be able to submit those plans or modify those plans with additional information to satisfy SBX7-7 Agriculture Water Management Planning Act (CWC Section10827).

CWC Section 10608.50(a)(1) mandated DWR (in consultation with the SWRCB) to promote implementation of regional water resources management practices through increased incentives and removal of barriers consistent with state and federal law. Among the potential tasks enumerated by the Legislation are the revisions to the requirements for urban and agricultural water management plans. As a result, and to assist agricultural water suppliers in complying with the requirements of the Agriculture Water Management Planning Act, DWR developed a draft Agricultural Water Management Planning Guidebook in 2012. The guidebook is meant to help agricultural water suppliers better understand the SB X7-7 requirements and assist them in developing their AWMPs. The Guidebook also provides information on how agricultural water suppliers may meet the requirements of the Agricultural Water Measurement Regulation and associated compliance documentation, as well as aggregated farm-gate delivery reporting format for Article 2 required by CWC Section531.10. The guidebook can be accessed on the web at: http://www.water.ca.gov/wateruseefficiency/sb7/committees/ag/a6/.

When applicable, an AWMP shall also include in addition to the required elements as specified by CWC Section10820 (a), other elements such as documentation to show compliance with the Agricultural Water Measurement Regulation (CCR Title 23, Division 2, Chapter 5.1, Section 597-597.4). The Agricultural Water Measurement Regulation requires specific documentation to demonstrate compliance. For example: If water cannot be measured at the farm-gate or delivery point, agricultural water suppliers that provide water to 25,000 irrigated acres or more must include certain agricultural water measurement documentation in their AWMP in accordance with Agricultural Water Measurement Regulation (CCR Section597.4(e)). Additionally, if an existing water measurement device is not and cannot be made compliant with the regulation, the AWMP must then include a schedule, budget, and finance plan for taking corrective action in three years or less (CCR Section597.4(e)(4)). Agricultural water suppliers providing water to 10,000 to 25,000 irrigated acres who are required to prepare an AWMP may have to incorporate agricultural water measurement documentation in their AWMP if implementation of agricultural water measurement has been funded as specified in CCR Section 597.4(e).

Methodology for Quantification of Efficiency of Agricultural Water Use

The SB X7-7 (2009) legislation directed the DWR—in consultation with the AWMC, academic experts, and other stakeholders—to develop and report to the Legislature a proposed methodology for quantifying the efficiency of agricultural water use and a plan of implementation that includes estimated implementation costs, roles and responsibilities, and types of data that would be needed to support the methodology. To carry out the mandate, DWR formed a second subcommittee of the ASC focusing on the quantification of efficiency of agricultural water use. DWR held numerous public listening sessions, stakeholder committee and subcommittee meetings, and public workshops to develop the methodology and prepare a report to the Legislature (submitted in July 2012). The legislation did not authorize DWR to implement the methodology. However, DWR recommends that if the proposed methodology is authorized for implementation, the Legislature should appropriate the necessary funding to cover its implementation costs as described in its report to the Legislature.

To develop a methodology to quantify the efficiency of agricultural water use, a water balance approach was considered to look into the various components of water use in agriculture including water used for environmental use associated with irrigated lands. Other uses of water in agriculture—dairy production areas, washing products, etc.—are not included in the water balance because they represent small fractions of the total water use in most cases and are difficult to quantify. The methodology proposed is composed of four consistent and practical methods for quantifying the efficiency of water use by irrigated agriculture. To develop the methods, DWR considered the components of a water balance at three spatial scales—basin, water supplier, and field—to understand and estimate through measurements or calculations how much water enters and leaves these areas. As a result, four methods were proposed for quantifying the efficiency of agricultural water use to help identify opportunities to improve the efficiency of water use at different spatial scales. The methodology is suitable for evaluating current conditions and strategies for improving agricultural water management on the diverse array of agricultural irrigation systems and operations found throughout California. The anticipated users of the methods are farmers, water suppliers, and basin water management groups, as well as nongovernmental organizations and local, State, federal, and tribal water planners.

The methods presented for quantifying the efficiency of agricultural water use are based on water use efficiency fractions that are a ratio of outputs from an agricultural system to an input to the agricultural system in volumes and/or depths of water. Input to an agricultural system is the volume of applied water. Outputs from agricultural systems include evapotranspiration from crops (ET), agronomic use such as leaching salts, evaporation during seed germination, climate control (frost protection and cooling), environmental water use, tailwater, deep percolation, evaporation from open water surfaces, and evapotranspiration by non-crops (weeds, for example). The ratio of selected outputs (crop evapotranspiration, crop agronomic use, and environmental water use) to inputs (applied water) is used to quantify the efficiency of water use. Other outputs (evaporation from soil or water surfaces in excess of ET, evapotranspiration by non-crop vegetation, and flow to salt sinks, etc.) are not quantified and may be estimated in total as residual in the water balance. Crop evapotranspiration, crop agronomic uses (leaching, evaporation during seed germination, evaporation for cooling or application for frost control) and evaporation and evapotranspiration for environmental purposes are intended uses (outputs).

The four methods—each of which evaluates a portion (fraction) of applied water—are:

- **Crop Consumptive Use Fraction (CCUF)**. This method evaluates the relationship (ratio) between the consumptive use of crop(s) and the quantity of water applied. CCUF is a fraction that shows the proportion of applied water that is consumed by the crop. It is applicable at the basin, water supplier, and field scales.
- **Agronomic Water Use Fraction (AWUF)**. This method calculates the ratio of agronomic use (salinity management, germination, etc.) and consumptive uses of crop(s) to the quantity of water applied. AWUF is a fraction that shows the portion of applied water used to grow the crop including crop consumptive use and agronomical use. It is applicable at the basin, water supplier, and field scales.
- **Total Water Use Fraction (TWUF)**. This method further expands on the CCUF and AWUF by evaluating the relationship (ratio) between water applied for crop consumptive use, crop agronomic use, and for environmental objectives and the quantity of applied water. TWUF accounts for all intended water uses; as a result, this fraction can be used as a measure of total water use efficiency. It is applicable at the basin, water supplier, and field scales.
- **Water Management Fraction (WMF)**. This method evaluates the relationship between crop consumption use and recoverable flows and quantity of applied water. This method estimates the recoverable water available for reuse at another place or time in the system. It is applicable at the basin and water supplier scales and is not intended for field scale.

DWR's Report to the Legislature on the proposed methodology included an implementation plan as well as the potential associated costs. The plan included a three-phase schedule of implementation and identified implementing entities, roles, data needs and sources, and data management. Implementation of the methodology would require new funding for DWR and water suppliers. The cost to DWR to support implementation of the proposed methodology is about $400,000 per year in addition to a onetime cost of $500,000 for developing a database. Estimated costs to water suppliers serving water to more than 25,000 acres or irrigated land (these suppliers account for approximately 6 million acres of irrigated land) would be about $6 million to $30 million per year (water measurement costs are excluded, since water delivery measurement to fields is required by CWC for these suppliers). Estimated costs to water suppliers serving water to more than 10,000 but less than 25,000 acres or irrigated land (these suppliers account for approximately 757,000 acres of irrigated land) would be about $8.8 million per year and a onetime cost of $15 million for installing water measurement devices.

In addition to the four methods for quantifying the efficiency of agricultural water use, DWR has included in this report four indicators that would provide supplemental information about irrigation and delivery system performance and crop productivity. These indicators do not quantify the efficiency of agricultural water use, but help estimate the limits of potential efficiency and productivity. Two of the indicators help describe the performance of the growers' irrigation system (how evenly water is applied and infiltrates into the soil) and the water supplier's delivery system (relationship of water diverted by the supplier to water delivered to its customers) —distribution uniformity (DU) and delivery fraction (DF).

- **DU** is a measure of irrigation system performance—how evenly water is applied and infiltrates into the soil across a field during an irrigation event. It is not a measure of how efficiently water is used on the field. A well designed irrigation system applies water to crops as uniformly as possible to optimize crop production. DU is applicable at the field scale. Under CWC Section10608.48(c), many water suppliers may provide on-farm irrigation evaluation service, if locally cost effective, that include the determination of DU and other information of the irrigation system.
- **DF** evaluates the relationship (ratio) between the water delivered to water supplier customers and the agricultural water supplier's water supply. It is applicable at the water supplier scale, only. Under CWC Section531.10 and CWC Section10608.48, many water suppliers are required to determine and report aggregated farm-gate delivery and water supply—the components used to calculate delivery fraction.

The other two indicators help describe crop productivity (relationship of the volume of water applied to an area to the total crop yield and gross crop revenue)—Productivity of Applied Water (PAW) and Value of Applied Water (VAW).

- **PAW** illustrates the relationship (ratio) between crop production in tonnage and the volume of applied water. It is most applicable at a statewide or county scale.
- **VAW** illustrates the relationship (ratio) between gross crop value in dollars and the volume of applied water. It is most applicable at the statewide and county scales.

The crop productivity indicators provide information about the relationship and trends of crop yield and/or monetary value to the volume of irrigation water applied during production. They can indicate long-term changes or trends in agricultural production and income relative to applied water at larger spatial scales. However, these indicators do not quantify the efficiency of agricultural water use nor economic efficiency. Crop production depends on many factors other than the water to meet crop consumptive and non-consumptive needs, including water quality, climate, soil type, soil depth, crop parameters (variety), crop management (fertilizer and pest management, etc.) and water management (irrigation system, irrigation management, and water supply flexibility and reliability). As a result, the crop productivity indicators should not be used to draw conclusions about regional crop selection because many factors other than applied water affect crop selection, crop production, and crop value in any given year and location and with changing crop markets.

Efficient Water Management Practices

Pursuant to the SB X7-7 legislation, certain agricultural water suppliers as defined in (CWC Section10608.12) shall implement on or before July 31, 2012 two specific critical EWMPs. These are stated in CWC Section 10608.48(b):

1. Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph (2).
2. Adopt a pricing structure for water customers based at least in part on quantity delivered."

Agricultural water suppliers have to implement 14 additional EWMPs when locally cost-effective and technically feasible (CWC Section10608.48 (c)). The 16 EWMPs, as stated by SB X7-7 Legislation, are listed in Box 2-2.

As part of the agricultural water use efficiency provisions, the SB X7-7 Legislation states that DWR may update the EWMPs in consultation with the AWMC, USBR, and SWRCB (CWC Section 10608.48(h)). These EWMPs for agricultural water use shall be adopted or revised only after DWR conducts public hearings to allow participation of the diverse geographical areas and interests of the state. Planning for this task is underway. Also, CWC Section 10608.48(g) also states that On or before December 31, 2013, DWR shall submit a report to the Legislature on agricultural EWMPs that have been and are planned to be implemented and an assessment of the manner in which the implementation of the EWMPs has affected and will affect agricultural operations an estimate of water use efficiency improvements. Subsequent reports will be prepared in 2016 and 2021. Additionally, DWR shall also prepare and submit to the Legislature a report summarizing the status of the submitted Agricultural Water management Plans, their outstanding elements, effectiveness of promoting EWMPs and recommendations relating to proposed EWMPs changes, as appropriate. Similar reports will subsequently be submitted in years ending in six and one. (Water Code sections 10845(a) through (c)).

As part of their AWMPs, agricultural water suppliers also required to "Report on which efficient water management practices have been implemented and are planned to be implemented, an estimate of the water use efficiency improvements that have occurred since the last report, and an estimate of the water use efficiency improvements estimated to occur five to 10 years in the future. If an agricultural water supplier determines that an efficient water management practice is not locally cost effective or technically feasible, the supplier shall submit information documenting that determination." (CWC Section10608.48 (d))

It should be noted that in addition to the EWMPs listed in Box 2-2, there are important cultural practices such as soil management, cover crops, changes in tillage practices, land management practices, winter storm water capture and use, dry farming and rain-fed farming that can reduce applied water and increase water use efficiency.

In 2011, the State Water Resources control Board and the Delta Stewardship Council published a report that examines the "reasonable use doctrine" (the constitutional principle that forbids waste and mandates that state water resources be used reasonably and beneficially) as it relates to agricultural water use efficiency. The report, entitled "The Reasonable Use Doctrine and Agricultural Water Use Efficiency," addresses how the State's Reasonable Use Doctrine may be employed to promote more efficient water use in the agricultural sector. The report shows that there is a wide array of irrigation practices in place today that result in the more efficient and therefore more reasonable use of water. The report concludes that the Reasonable Use Doctrine may be employed to promote a wider use of such efficient practices. The report recommends that the State Water Board convene a Reasonable Water Use Summit and contains specific recommendations for consideration during the Summit. The recommendations range from a wider employment of efficiency practices such as improvements to the irrigation systems that deliver water to farms, weather-based irrigation scheduling, and more efficient irrigation methods.

Reference:
http://www.waterboards.ca.gov/board_info/agendas/2011/jan/011911_12_reasonableusedoctrine_v010611.pdf

A March 2010 report by the Pacific Institute, "California Farm Water Success Stories" consisting of a follow-up to the 2009 report, identified and analyzed some successful case studies of sustainable agricultural water management policies and practices in the California. The examples highlighted both on and off the farm activities that led to more efficient applied water use or enhanced water quality, increased crop yields or quality, and provided multiple benefits. Such activities included planning and management practices, technological improvements, information dissemination, use of recycled water, and incentive and assistance programs.

In June 2011, the California Roundtable on Water and Food Supply issued a set of recommendations in a report entitled "Recommendations to Optimize Outcomes for Specialty Crop Growers and the Public in California" addressed to state agencies, water suppliers, local water management groups, the agricultural community, and the research community. The Roundtable is a forum of leaders in food production and water to uncover obstacles, identify strategic and widely accepted solutions, and generate recommendations to assure a reliable, long-term supply of water to California's specialty crop producers while optimizing other beneficial uses of water. The Roundtable identified agricultural water stewardship as a key area of importance for sound long-term water, where 'agricultural water stewardship' was defined as the utilization of water on-farm in a manner that optimizes beneficial uses of water and recognizes the co-benefits of water for food production and environmental and human health. The specific recommendations are centered around three key solution themes with the goal of improving and promoting agricultural water stewardship: (i) Create a stronger knowledge base; (ii) Improve support mechanisms for growers; and (iii) Move toward outcome-based policy and regulatory frameworks that foster agricultural water stewardship.

A July 2011 report by the Northern California Water Association (NCWA) entitled "Efficient Water Management for Regional Sustainability in the Sacramento Valley," presents a framework for addressing agricultural water use efficiency in the Sacramento Valley while considering the valley's hydrologic characteristics and existing conditions. The report outlines a technical framework to guide water use efficiency efforts in the Sacramento Valley by providing water resources managers with tools to identify, assess, and pursue specific water use efficiency opportunities while stressing the need for achieving regional sustainability. While recognizing that potential water use efficiency improvements have statewide as well as local and regional benefits, the report point out the challenge to Sacramento Valley water managers in developing coalitions within and outside the valley to garner the necessary resources to advance water use efficiency for achieving regional sustainability and statewide benefits.

Growers invest in on-farm water management improvements to stay economically competitive. Likewise, local water suppliers invest in cost-effective, system-wide water management improvements in order to provide quality service at a fair and competitive price. In addition to water savings, efficiency measures can provide water quality and flow-timing benefits. The CALFED Bay-Delta Program's (CALFED) Quantifiable Objectives (QOs) and Targeted Benefits (TBs) — which can be local, regional, or statewide — are numeric targets that address CALFED objectives of water supply reliability, water quantity, water quality, flow and timing for ecosystem improvements, and other benefits such as energy efficiency. Due to the complexity of QOs and lack of technical information on QOs for different CALFED solution regions, DWR has increasingly emphasized TBs and has incorporated TBs into its water management planning and implementation efforts as well as emphasizing TBs through the grant program.

Substantial financial support for research, development, and the demonstration of efficient water management practices in agriculture comes from the agricultural industry and State and federal efforts. Support also comes from the early adopters of new technology who often risk their crops, soils, and money when cooperating to develop and demonstrate technology innovations. Further investments in research and demonstration are critical, especially in support of university-based research, field station studies, and cooperative extension demonstration projects.

Improvements in agricultural water use efficiency primarily occur from three activities:

- Hardware. Improving on-farm irrigation systems and water supplier delivery systems
- Water management. Reducing non-beneficial evapotranspiration and improving management of on-farm irrigation and water supplier delivery systems.
- Agricultural technology: breeding, GMO crops, fertilizers technology, etc.

Hardware Upgrades

Due to water delivery system limitations, growers are often unable to apply the optimal amount of irrigation water. Water delivery system improvements such as integrated supervisory control and data acquisition systems (SCADA), canal automation, regulating reservoirs, and other hardware and operational upgrades, can provide flexibility to deliver water at the time, quantity, and duration required by the grower. At the on-farm level, many old and most new orchards and vineyards, as well as some annual fruits and vegetables, are irrigated using pressurized irrigation systems (Figure 2-1 shows irrigated acreages by irrigation method.).

Almost all trees and vines established since 1990 are irrigated using micro-irrigation. Between 1991 and 2011, the crop area under micro irrigation in California grew from 1.26 million to 3.12 million acres, a 150% increase (see Figure 2-2 and Table 2-1).

A survey of more than 10,000 growers in California (excluding rice, double cropping, dry-land, and livestock producers) was conducted by DWR Land and Water Use program (Orang et al., 2011) to investigate current trends in irrigation methods used statewide. Results from the survey indicate that the land acreage irrigated by low-volume irrigation methods (drip and micro sprinklers) has increased by 16%

percent between 2001 and 2011, while the acreage of land irrigated by surface irrigation methods has decreased by 13% (Figure 2-3).

PLACEHOLDER Figure 2-1 Acres of Irrigated Agricultural Land by Irrigation method in California in 2010

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

PLACEHOLDER Figure 2-2 Change in Irrigation Methods in California (1977-2010)

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

PLACEHOLDER Figure 2-3 Statewide Trends in Irrigation Method Area from 1991 to 2011

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

Many growers use advanced irrigation systems for irrigation, fertilizer application, and pest management. Advanced technologies include geographic information system (GIS), global positioning system (GPS), and satellite crop and soil moisture sensing systems. These technologies allow growers to improve overall farm water management.

The use of pressurized irrigation systems, such as sprinkler, drip, and micro-spray, in addition to being energy intensive, often requires modernization of water supplier delivery systems to provide irrigation water at the time, quantity, and duration required by the grower. Increasingly, water suppliers are upgrading and automating their systems to enable accurate, flexible, and reliable deliveries to their customers. Also, suppliers are lining canals, developing spill recovery and tail water return systems, employing flow regulating reservoirs, improving pump efficiency, and managing surface water conjunctively with groundwater. With the advancement of both water supplier and on-farm water management systems, there is potential to improve irrigation efficiencies at both on-farm and water supplier levels.

Growers continue to make significant investments in on-farm irrigation system improvements, such as lining head ditches and using micro-irrigation systems. Many growers take advantage of mobile laboratory services to conduct in-field evaluation of irrigation systems. Once considered innovative technologies, these are now standard practice. In terms of future improvements, the California Polytechnic State University, San Luis Obispo, Irrigation Training and Research Center estimates that an additional 3.8 million acres could be converted to precision irrigation such as drip or micro-spray irrigation (Burt, et al., 2002). While this will not reduce crop water consumption, it can improve the uniform distribution of water and reduce evaporation, thus allowing more efficient use of water. Research on drip irrigation of alfalfa has shown an applied water reduction of two to three percent with yields increasing from 19 to 35 percent, an increase in productivity of 30 percent with the same amount of applied water. Conversion of traditional irrigation systems to pressurized systems and installation of advanced technologies on water supplier delivery systems require more investment in facilities as well as use of additional energy that increases farm production costs and water supplier operational costs. The additional cost of such improvements is a challenge for many water suppliers. California Farm Water

Coalition, based on industry contacts, reports that in the six-year period from 2003 through 2008, San Joaquin Valley farmers invested over $1.5 billion in high efficiency irrigation equipment (not annualized cost).

PLACEHOLDER Table 2-1 Trends in Irrigation Method Area (in Million Acres)

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

Trends in irrigation methods used vary by region; such variation is mainly linked to the type of crops grown. Where more fruit trees and row crops (e.g., tomatoes) are grown, we see a larger increase in the use of drip and micro irrigation systems.

(**Note:** Following charts on the regional trends in irrigation method areas will be superimposed on the State's Hydrologic Regions Map.)

PLACEHOLDER Figure 2-4 Regional Trends in Irrigation Method Areas

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

Water Management

Both on-farm and water supplier delivery systems must be managed to take advantage of cost effective new technologies, science, and hardware. Personal computers connected to real-time communication networks and local area networks allow transmission of data to a centralized location. These features enable water supplier staff to monitor and manage water flow and to log data. With such systems, the water supplier staff spends less time manually monitoring and controlling individual sites, allowing them to plan, coordinate system operation, and potentially reduce costs. Such systems improve communications and provide for flexible water delivery, distribution, measurement, and accounting.

Some growers use satellite weather information and forecasting systems to schedule irrigation. Many growers employ evapotranspiration and soil moisture data for irrigation scheduling. Users generate more than 70,000 inquiries per year to the California Irrigation Management Information System (CIMIS), DWR's weather station program that provides Evapotranspiration (ET) data. Universities, water suppliers, and consultants also make this information available to a much wider audience via newspapers, Web sites, and other media.

Growers use many other water management practices. Furrow, basin, and border irrigation methods have been improved to ensure that watering meets crop water requirements while limiting runoff and deep percolation. Growers use organic or plastic mulch to reduce non-essential evaporation of applied water, minimize weed growth, and improve crop growth and productivity value. Agricultural land stewardship practices (see Chapter 20) also reduce water use and contribute to sound on-farm water management.

Reducing Evapotranspiration (ET)

ET is the amount of water that evaporates from the soil and transpires from the plant. Growers can reduce ET by reducing unproductive evaporation from the soil surface, eliminating weed ET, and shifting crops to plants that need less water, or reducing transpiration through deficit irrigation. In addition, some growers deficit irrigate their crops during water short periods and for agronomic purposes. Management practices such as mulching, use of cover crops, no-till and minimum tillage, and dust-mulching associated with dry farming reduce unnecessary evaporation from soil surfaces. Some of these management/cultural practices have energy conservation components as well.

Potential Benefits and Costs of Agricultural Water Use Efficiency

Several analyses have been performed since 2000 to quantify water savings and associated costs. The following is a summary of those analyses.

The CALFED Programmatic Record of Decision (ROD) estimates of 2000 estimated that efficiency improvements could result in a water savings (reduction in irrecoverable flows, also referred to as net water savings) ranging from 120,000 to 563,000 acre-feet per year (AFY) by 2030 at a cost ranging from $35 to $900 per acre-feet (CALFED, 2000a). The total cost of this level of agricultural water use efficiency to year 2030 is estimated at $0.3 billion to $2.7 billion, which includes $220 million for lining the All-American Canal and Coachella Branch Canal. The cost estimates are derived from potential on-farm and water supplier efficiency improvements associated with savings in irrecoverable flows. Details of estimates and assumptions are in the CALFED Water Use Efficiency Program Plan (CALFED, 2000b).

The analysis was based on improving on-farm efficiency up to 85 percent. It was assumed that the achieved 85 percent on-farm efficiency would be maintained afterward. Technical, management, and hardware limitations to achieve high performance levels for irrigation systems restrict irrigation distribution uniformities and on-farm efficiencies up to 85 percent, beyond which a sustainable and healthy soil environment cannot be maintained. Higher than 85 percent irrigation efficiencies result in soil salinity, soil degradation, and loss of productivity.

The study also estimated a 1.6 MAF per year reduction in applied water (recoverable flows) that provide environmental and crop production benefits. The estimated water savings are from all hydrological regions as defined in the California Water Plans.

Estimates of water savings and benefits resulting from land retirement, crop shifts, crop idling, and reducing crop transpiration through regulated deficit irrigation were not quantified in the ROD estimates. (See Box 2-5 for discussion of regulated deficit irrigation.)

PLACEHOLDER Box 2-5 Regulated Deficit Irrigation

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

In the Colorado River Hydrologic Region, water use efficiency measures are being driven by the Quantification Settlement Agreement. QSA projects will reduce irrecoverable flows by 67,700 AFY at a cost of $135.65 million by lining the All-American Canal and by 26,000 AFY (at a cost of $83.65 million) by lining the Coachella Branch Canal, for a total of 93,700 AFY (CALFED, 2000b).

Under the QSA, agricultural water use efficiency measures adopted by the Imperial Irrigation District (IID) by 2026 will result in a reduction in delivery of Colorado River water to IID of 487,200 AFY (inclusive of 67,700 AFY reductions from the All-American Canal lining). The 26,000 AFY Coachella Branch Canal lining is subtracted from the Coachella Valley Water District use. However, CVWD will receive conserved water from IID, and over the term of the QSA, its overall consumptive use will increase by 77 thousand acre-feet per year (TAFY) by 2026 and for the duration of the QSA (Secretary of the Interior, et al., 2003, page 13). It should be noted that the IID/Metropolitan Water District of Southern California (MWD) transfer has been fixed at 105 TAFY instead of 110 TAFY. Water conserved under the QSA will not result in new water supplies for California; rather, it provides a portion of the reduction needed for California water users to reduce their use of Colorado River water by 800,000 AFY– from 5.2 to 4.4 MAF per year (DWR, 2009a; Secretary of the Interior, et al., 2003; USBR, 2003).

The 2006 CALFED Water Use Efficiency Comprehensive Evaluation (Comprehensive Evaluation) estimated potential water savings for different projection levels, ranging from 34,000 to 190,000 AFY of irrecoverable water and 150,000 to 947,000 AFY of recoverable water (CALFED, 2006). These estimates were for different projection levels, based on costs ranging $15 million to $40 million annually (Table 2-2). The cost is for implementation of efficiency measures that are not locally cost-effective regardless of who funds the implementation. It is also assumed that implementation of all locally cost-effective efficiency measures are and will continue to be paid by local agencies and growers. The analysis also provided the maximum water savings achievable at the field and district levels if cost were no barrier. Water savings at this projection level (PL) is called technical potential (Projection Level 6 or PL-6). Technical potential was defined as the savings resulting from 100 percent adoption of all agricultural water use efficiency actions/measures statewide, and assumed that all technically demonstrated practices would be implemented regardless of cost. The technical potential or PL-6 water savings, at an estimated cost of $1.6 billion, are 1.8 MAF per year irrecoverable water savings and 4.3 MAF per year recoverable water savings. PL-6 was determined to be unrealistic both with respect to State’s ability to provide such large funds and level of water savings, and impractical. PL-6 represents a perfect irrigation system and management performance not attainable in production agriculture. The analysis also indicates the potential for additional water savings of 142,000 AF annually from regulated deficit irrigation (independent of projection levels). Figure 2-5 presents average and incremental costs per acre-foot of irrecoverable flows for all projection levels in this study. The Comprehensive Evaluation estimated water conservation based on on-farm hardware and irrigation management improvements and district improvements. The study did not include potential savings in the Colorado River Hydrologic Region that are already committed to and funded by efficiency conservation water transfer agreements. Nor, as noted above, will these be included in potential agricultural water use efficiency reductions for the state, because they only account for reductions to meet California’s Colorado River water rights.

PLACEHOLDER Table 2-2 On-Farm and Water Supplier Recoverable and Irrecoverable Flow Reductions

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

PLACEHOLDER Figure 2-5 [Title needed]

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

On-farm water use improvements were analyzed based on natural replacement from lower to higher performing systems over time as well as various funding levels. Water supplier improvements were basementation of efficient water management practices and various funding levels. The potential savings estimated in the Comprehensive Evaluation are based on a set of specific assumptions about the distribution and effective use of investments in agricultural water use efficiency (CALFED, 2006). The cost information in Table 2-2 represents the investment in water use efficiency actions beyond the estimated locally cost-effective actions.

A July 2009 report from the Pacific Institute, “Sustaining California Agriculture in an Uncertain Future,” is another analysis to quantify agricultural water savings (Cooley, et al., 2009). The report estimates potential water savings from 1) efficient irrigation technologies, 2) improved irrigation scheduling, and 3) regulated deficit irrigation, under three statewide hydrologic scenarios, i.e., wet, average, and dry year conditions. The total potential water savings range between 4.5, 5.5, and 5.9 MAF per year for wet, average, and dry years respectively. The report does not separate its quantitative estimates between recoverable and irrecoverable water savings, thus the potential water savings are applied water savings only.

There is no doubt that agricultural water use efficiency can still be improved by continuing current trends such as improving irrigation efficiency, adopting drip and micro irrigation, adopting reduced deficit irrigation, selecting water efficient crops, etc. However, the potential for water savings from agricultural water use efficiency has been the subject of a broad debate. At the high end, some reports mention potential savings as high as 5 million acre-feet of water per year by the year 2030 (Pacific Institute 2005 report “California Water 2030: An Efficient Future). Others caution that any approach used to estimate the potential of developing new water supplies through agricultural water conservation needs to acknowledge the difference between recoverable and irrecoverable flows; more importantly potential water savings should be tied to different levels of investment (Center for Irrigation Technology (CIT) 2011 report: Agricultural Water Use in California: A 2011 Update). The CIT report concludes that the potential of large volumes of “new water” from agricultural water conservation does not exist unless large swaths of agricultural land are taken out of production, which technically is not water use efficiency. Also, among the report findings: (i) The estimated potential of new water from agricultural water use efficiency is 1.3% of the current amount used by the farmers or about 330,000 acre-feet per year (at funding level PL-5 identified in the Water Plan Update 2009). That represents about 0.5 % of California’s total water use. (ii) Changes in irrigation practices, such as switching from flood irrigation to drip, have the effects of rerouting flows within the region (or basin) but generally do not create new water outside of the basin. (iii) On-farm water conservation efforts can affect downstream water distribution patterns, with potential impacts on plants and animals, recreation, as well as human and industrial consumptive uses. Effects can be positive or negative and also inconsistent (e.g., on-farm conservation could reduce a city’s water supply but improve the nonpoint source situation).

Water Supplier Water Use Efficiency

Water use efficiency estimates at the water supplier level are based on cost and performance of supplier management changes and infrastructure improvements. A regional baseline of water supplier improvements was developed by CALFED based on water availability and knowledge of local delivery capabilities and practices. In addition, it was assumed that all locally cost-effective efficient water management practices would be implemented. The initial investment for improvements was allocated for management changes that provide an improved level of delivery service—mainly through additional labor and some system automation. Higher levels of water supplier delivery system performance would be achieved through infrastructure improvements such as regulating reservoirs, canal lining, additional system automation, and spill prevention.

At the water-supplier level, most benefits may occur as a result of managing recoverable flows through return flows and spill recovery systems. However, since recoverable flows, especially surface return flows, are typically being used by downstream farming operations, the location of the water diversion in the basin is critical for determining if implementing a water use efficiency measure would adversely reduce the supply of downstream agricultural water users. Consequently, many consider the reduction of irrecoverable flows (or net water use) a better estimate of potential agricultural water use efficiency.

On-Farm Water Use Efficiency

On-farm water use efficiency estimates are based on cost and performance information for feasible irrigation systems. Depending on crop type, irrigation systems can include various forms of un-pressurized surface irrigation (furrow and border strip), and pressurized irrigation systems (variety of sprinkler and drip). The performance of any irrigation system also depends on how well it is managed. For a given crop, the irrigation system and management will determine the water use characteristics—how much of the applied water is used beneficially and how much is irrecoverable. Irrecoverable flows include those to transpiration, saline sinks, and non-beneficial evaporation. Recoverable flows encompass surface runoff and deep percolation to usable water bodies. The recoverable flow results are based on the QOs that express instream flow needs for Bay-Delta tributaries. It is important to note that the assumption that all recoverable flows may end up benefiting instream flows may not be valid. Much of efficiency improvements may increase water use as a result of larger plants, higher yields, and increased irrigated acreage. Although recoverable and irrecoverable flow reductions are reported separately for on-farm and water suppliers, it is not appropriate to assign benefits solely to on-farm or water suppliers due to the strong connection between on-farm recoverable flows and water supplier efficiency improvements. See also Box 2-6, Interrelation between On-farm and Regional Efficiencies and Role of Water Reuse.

PLACEHOLDER Box 2-6 Interrelation between On-farm and Regional Efficiencies and Role of Water Reuse

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

A primary environmental benefit of water use efficiency actions is the improvement in aquatic habitat through changes in instream flow and timing. Additional benefits may include water quality improvements by reducing water temperature, subsurface drainage flows, and reducing contaminant loads. Growers may reduce pumping costs and may provide and/or receive water quality benefits by complying with pollutant reduction rules under the State's total maximum daily load requirements (TMDL). However, depending on the timing of flow changes, improvements in water use efficiency can cause negative environmental effects, such as reduced runoff to downstream water bodies and increased concentration of pollutants in drain water unless the drainage water contaminants (such as selenium) are isolated and properly disposed of. The QOs flows represent the aggregate instream Bay-Delta watershed flow needs that can potentially be met through water use efficiency actions. When comparing the recoverable flows to the QOs flows and TBs, it is important to remember that the instream flow needs are location and time specific—thus an acre-foot to acre-foot comparison is not appropriate.

Major Issues Facing Agricultural Water Use Efficiency

Funding

Beginning in 2000, the State has implemented several cycles of loan and grant programs for water use efficiency improvements. The funds have been through successive competitive proposal solicitation packages (PSP) for projects on a cost-sharing basis for water use efficiency projects that may not be locally cost-effective. The grant cycles are summarized in Table 2-3.

PLACEHOLDER Table 2-3 Projects Funded through Water Use Efficiency Grant Cycles

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

Funds dedicated to water use efficiency have fallen below estimates of the 2000 CALFED ROD that called for an investment of $1.5 billion to $2 billion from 2000 to 2007. The CALFED ROD stated that State and federal governments would fund about 50 percent (25 percent each), with local agencies paying for the remaining 50 percent of CALFED water use efficiency activities. To put funding shortfall in perspective, as shown in Figure 2-6, for the 10-year period from 2000 through 2009, the total funding for agricultural water use efficiency projects has been $26.2 million. This constitutes a $2.6 million expenditure annually compared to $214 million to 285 million annually, 0.1 percent of funds envisioned by CALFED. Prop. 84 Integrated Regional Water Management grants provided a one-time $10 million grant for agricultural water use efficiency projects. If voters approve The Safe, Clean, and Reliable Drinking Water Supply Act of 2010 (legislative initiative SBx7 2) in the November 2010 general election, it is anticipated that the act will provide a total of $125 million for agricultural water use efficiency projects. Again, this is a one-time allocation and will constitute no more than 1.5 percent of $150 million annual cost to the State to achieve estimated water savings.

PLACEHOLDER Figure 2-6 [Title needed]

[Any draft tables, figures, and boxes that accompany this text for the advisory committee draft are included at the end of the chapter.]

Although the need is great, small and disadvantaged communities may not be able to apply for State and federal grants since they have limited funds. In addition, such water suppliers rarely have the technical and financial abilities to develop plans or implement expensive water management practices. During the last two Proposition 50 water use efficiency grant cycles, DWR has made significant efforts, and will continue to do so with the agricultural water use efficiency 2012 grant cycle, to provide technical and financial assistance to disadvantaged communities. SBx7 7, passed in the 2009-2010 legislative session, requires DWR, in the allocation of funding, to give consideration to disadvantaged communities.

For some water suppliers, funding for water use efficiency comes from the ability to transfer water, such as in the Colorado River region. While transfers to urban areas may reduce the amount of water available to grow crops, they are expected to play a significant role in financing future water use efficiency efforts.

Implementation

Implementation of agricultural water use efficiency depends on many interrelated factors. Farmers strive to maximize agricultural profits per unit of land and water without compromising agricultural economic viability, water quality, or the environment. Success depends not only on availability of funds but also on technical feasibility and cost-effectiveness, availability of technical assistance, and ability and willingness of growers, the irrigation industry, and water suppliers. Other factors such as soils and topography, micro-climate, markets, etc., play important roles as well. Implementation of efficiency measures requires consideration for crops grown, groundwater and/or surface water availability, and water quality within each geographic area. Opportunities exist to implement efficiency measures beyond efficient water management practices to provide water quantity, water quality, flow and timing, energy efficiency, and other benefits to the growers and local water suppliers and to provide regional or statewide benefits. Comprehensive implementation of efficiency measures must, to the extent possible, include multi-purpose and multi-benefit projects.

Regulated Deficit Irrigation

Reducing ET requires precise application of water. Stressing crops through regulated deficit irrigation (RDI) is one approach that requires careful scheduling and application of water and may have additional costs and adverse impacts on crop quality or soil salinity. RDI long-term studies are underway and results differ by crop, location, and year. (See also Box 2-5 for discussion of regulated deficit irrigation.)

Water Rights

Many growers and irrigation districts are concerned about existing and potential water use efficiency legislation and believe that implementing efficiency measures could affect their water rights. They believe that conserved water may be used by others, causing a loss of rights to the use of conserved water. This belief may impede implementation of water use efficiency strategies. It should be noted that the water rights of agencies implementing efficiency measures have been protected. One example is the conservation efforts of IID (funded by MWD, SDWA, and others) that resulted in water being transferred to urban uses, while IID’s water rights are protected.

Energy and Water Relationship

The relationship between water use efficiency and energy use/carbon footprint is complex and needs to be thoroughly studied and understood. Improved agricultural water use efficiency may or may not help to reduce energy use—and thus reduce GHG. This is because of the complex relationship between GHG emissions, the use of energy (use of natural gas and the use of fossil fuel), and efficient use of water. It appears that decreased use of one resource, through implementation of efficiency measures, increases the use of another resource, which may neutralize or greatly impact net outcome, and often has more overall adverse effects than intended or desired. Not enough studies and research have been conducted to quantify the relationship between agricultural water use efficiency and energy use.

By considering the embedded energy of irrigation water—which is the energy required to deliver water to the field, CSU Fresno Center for Irrigation Technology shows in its 2011 report that water use efficiency may reduce or increase energy use. By reducing irrigation water through water use efficiency, generally the embedded energy would always be saved. However, the water use efficiency method employed might require a change in the irrigation system (e.g., changing the irrigation system from flood to drip). In such a case, even though the embedded energy is reduced, the energy required to apply the water to the field is increased. As a result, whether water use efficiency results in a net decrease or increase in energy use depends on the amount of water saved, the level of embedded energy, and the additional energy required to pressurize the irrigation system.

Climate Change

One of the most critical impacts on California agriculture may be the projected reduction in Sierra Nevada snowpack—California's largest surface "reservoir". Snowmelt currently provides an annual average of 15 MAF of water, slowly released between April and July each year. Much of the state's water infrastructure was designed to capture the slow spring runoff and deliver it during the peak of the agricultural water use season. Based upon historical data and modeling, DWR projects that the Sierra snowpack will experience a 25 to 40 percent reduction from its historical average by 2050. Climate change is also anticipated to bring warmer storms that result in less snowfall at lower elevations, reducing the total snowpack. With warming temperatures the snowpack will melt earlier in the season with less late-season runoff. Warming temperatures and increased atmospheric concentrations of CO2 also increase evapotranspiration and crop water demand. All of these factors will further stress California's agricultural community (DWR, 2008, 2009b, 2010).

Mitigation

On-farm and water supplies water use efficiency improvements often require additional energy. Conversion of furrow irrigation to drip or sprinkler would require significant energy, even though growers and/or water suppliers may pump less water, which then may reduce energy use. Yet, the overall result of such efficiency practices may be a net increase of energy use. Water supplier infrastructure improvements often affect upstream-downstream water use, and the increasing use of pressurized irrigation systems by growers requires the use of additional energy resources such as electricity, gas, and diesel. Pressurized systems also require pipelines, pumps, filters and filtration systems; chemicals for cleaning drip systems; and replacement and disposal of the hardware after its useful life. Consequently, significant additional energy is required for manufacturing of pipelines, pumps, filters and filtration systems, chemicals, replacement and disposal of the hardware. Likewise, pressurized irrigation systems will need energy to produce required pressure in the pipelines for irrigation. Such additional energy will significantly increase GHG contributing to climate change. Water use efficiency efforts not only increase energy use, but also often shift use of energy and resources to other parts of the production system. Within the agricultural setting, the net impact of reduced water use and increased water use efficiency on the energy use and consequently on net carbon footprint, water footprint, and GHG emissions calls for study and quantification of such impacts.

Adaptation

Agricultural water use efficiency is an adaptive strategy to climate change. The ability to use water in a way that is most effective to the crop, while minimizing losses helps the grower to be resilient and flexible. Climate change is a major challenge to the sustainability of agriculture. The water use efficiency strategies discussed above are part of our adaptive capacity, but California growers must find a way to store more water in preparation for having access to less water during peak growing months in addition to using that water efficiently. Cover cropping and organic material build-up in soil are other methods of increasing water retention of fields, lessening the amount of irrigation water needed.

Other Implementation Issues

Other water use efficiency implementation issues that need to be evaluated include 1) concerns over groundwater impacts, overdraft, and loss of recharge, 2) increase in the vulnerability of trees and vines to hardening of demand, and 3) unpredictability of changing climate. Climate change is expected to impact water use since rising temperatures will result in higher ET and higher crop water use requirements.

Education and Training

Improving agricultural water use efficiency depends on disseminating information on the use, costs, benefits, and impacts of technologies and on providing incentives for implementation. Existing evidence, although limited, indicates a strong response to financial incentives. In addition, while the Water Code provides certain water rights protections and incentives to conserve water, reaffirming and reinforcing such mechanisms could significantly improve results statewide. Education and training programs can emphasize the potential benefits and risks of efficiency improvements; for example, soil sustainability from a salinity stand point, energy impacts and so forth.

Dry-Year Considerations

In dry years, California's water supply is inadequate to meet its current level of use, and agriculture often is faced with a reduction in water deliveries. Growers are compelled to reduce irrigated acreage to cope with the lack of water and implement extraordinary water use efficiency or even land fallowing. While agricultural water suppliers deal in a variety of ways with water shortages and droughts, there is a need for an agricultural drought guidebook.

Recommendations to Achieve More Agricultural Water Use Efficiency

The following recommendations can help facilitate more agricultural water use efficiency:

Funding

1. The State should identify and establish priorities for grant programs and other incentives. This should include a process for quantifying and verifying intended benefits of projects receiving State loans and grants. Priority funding may be for technical, planning and financial assistance to improve water use efficiency including implementation, monitoring, and reporting of certain programs for specific geographic areas of the state, or priority funding for projects that are not only cost-effective efficient water management practices (EWMPs), but also are part of the Integrated Regional Water Management Plans. Likewise, projects that include clear and well defined Targeted Benefits (including water quality, flow and timing, energy conservation, and overall environmental benefits) may be given high priority.
2. The State should provide funding to agricultural water suppliers serving less than 25,000 acres of irrigated land for the implementation of SB X7-7 water use efficiency requirements to include compliance with the measurement regulation.
3. The State should cooperate with a broad section of the agricultural community, including representatives of small farms and disadvantaged farmers and communities, to fund research, development, demonstration, monitoring and evaluation projects that improve cost-effective agricultural water use efficiency and support programs that encourage the development of new cost-effective water savings technologies and practices. In the case of reduced deficit irrigation (RDI), research is needed to evaluate the level of current practices, extent of implementation of

these practices, and quantification of RDI benefits and short and long-term impacts of RDI on plant longevity and productivity.

4. State loans and grants should provide ample opportunities for small water suppliers and economically disadvantaged communities, Tribes, and not-for-profit community-based organizations to benefit from technical assistance, planning activities, and incentive programs based on environmental justice policies. The Agricultural Water Management Planning Act in SB7x 7 requires DWR, when allocating loan and grant funds, to give special consideration to disadvantaged communities.
5. The State should provide additional funding for long-term evapotranspiration (ET) reduction (regulated deficit irrigation, mulch, alfalfa dry down, etc.) demonstration and research plots and fund other promising programs to reduce ET.

Implementation

6. DWR and the Department of Food and Agriculture, in cooperation with the Agricultural Water Management Council, should develop Targeted Benefits specific to different hydrologic regions of California. Targeted Benefits include improvements in water quality, flow and timing, and energy conservation.
7. The Agricultural Water Management Council should continue to incorporate Targeted Benefits within the agricultural water management planning and implementation process, where applicable, in addition to quantifying other benefits of improved water efficiency, including water supply.
8. The Agricultural Water Management Council should continue to encourage more water suppliers to sign the Memorandum of Understanding to broaden its base of support. The Council should seek the support of State and local agencies, as articulated in the MOU, for full implementation of efficient water management practices by signatories and encourage the addition of new efficient practices as benefits are identified.
9. The State should clarify policy and improve incentives, assurances, and water rights protections to allay fears over the loss of water rights resulting from improved water use efficiency. State should verify and clarify in its programs, especially loans and grant programs, that efforts to conserve water do not alter water rights. SB X7-7 legislation declares that it “does not require a reduction in the total water used in the agricultural or urban sectors, because other factors, including, but not limited to, changes in agricultural economics or population growth may have greater effects on water use. This part does not limit the economic productivity of California’s agricultural, commercial, or industrial sectors.” (CWC Section 10608.8(3)(c)).
10. DWR in cooperation with the Department of Food and Agriculture and other State agencies should implement the provisions of SBx7 7 regarding review of agricultural water management plans, preparation of required reports to the Legislature, and evaluation of and updating of agricultural efficient water management practices.
11. DWR, in cooperation with educational institutions, should provide technical assistance to water suppliers and farmers in evaluating their efficiencies of agricultural water use by computing the efficiency quantification methods outlined in DWR’s 2012 report to the Legislature “A Proposed Methodology for Quantifying the Efficiency of Agricultural Water Use.”
12. DWR should continue developing, in consultation with the State Water Board, the California Bay-Delta Authority or its successor agency, the California Department of Public Health, and the Public Utilities Commission, a single standardized water use reporting form to meet the water use information needs of each agency.

13. DWR should provide technical assistance to water suppliers to help them with the implementation of the agricultural water measurement regulation and the reporting of aggregate farm-gate deliveries so as to comply with the measurement regulation. .

Data Measurement and Evaluation

14. DWR should create a statewide system of water use monitoring data available to all users.
15. The State should expand water-efficiency information, evaluation programs, and on-site technical assistance provided through agricultural extension services and other agricultural outreach efforts.
16. The State should improve online data collection and dissemination networks to provide farmers with immediate meteorological and hydrological information on climate, soil conditions, and crop water needs.
17. The State should collect, manage, and disseminate statewide data on the cropped area under various irrigation methods, amount of water applied, crop water use, and the benefits and costs of water use efficiency measures. The State should also develop statewide guidance to assist regions and water suppliers to collect the type of data needed in a form usable for future Water Plan Updates. DWR and the Department of Food and Agriculture should work with the Agricultural Water Management Council to develop a database of information from the water management plans on water use-related data, and information generated from implementation of AB 1404. AB 1404 requires water suppliers to report to DWR aggregate farm-gate delivery data on a monthly or bimonthly basis, for dissemination and use in the Water Plan Update. DWR should work with CALFED Bay-Delta Authority to implement the recommendations of the Independent Panel on the Appropriate Measurement of Agricultural Water Use.
18. The State should cooperate with the agricultural community to develop methods to quantify water savings and costs associated with hardware upgrades, water management, and ET reduction projects identified in this strategy.
19. The State should incorporate in its definitions of “efficiency measures”, and “cost-effectiveness” ownership and operating costs, including labor, energy, and cost of maintenance.
20. The State should develop performance measures for water use efficiency goals and inform the public and stakeholders of accomplishments toward those goals. These performance measures should be updated to reflect new findings and changing conditions.
21. DWR in cooperation with the Department of Food and Agriculture should establish an on-farm irrigation system evaluation program, such as mobile labs, statewide. The irrigation system evaluation program provides valuable assistance to growers to further improve the performance of their irrigation systems.
22. Using data and information from on-farm efficiency improvements, as collected by mobile labs, DWR should quantify changes in irrigation system distribution uniformity improvements. The data also can help to quantify on-farm and regional efficiency and quantify improvements.
23. DWR should prepare reports on the results of efficiency improvements in irrigation systems to the Legislature and the public.

Education and Training

24. Expand CIMIS (including the use of remote sensing technology, satellite imagery, etc.) mobile laboratory services and other training and education programs to improve distribution uniformity, irrigation scheduling, and on-farm irrigation efficiency, as well as improvements in pumping

system efficiencies, remote control technologies and telemetry, canal automations, flexible water delivery systems, and irrigation system design.

25. Based on long-term ET reduction studies and research, DWR should develop informational guidelines that define the crop water consumption reduction practices, identify how they can be implemented for each crop, and estimate the potential crop benefits and impacts, water savings, and costs for growers and water suppliers.
26. Develop community educational and motivational strategies for conservation activities to foster water use efficiency, with the participation of agricultural and water industries and environmental interests. Develop partnerships with State, federal, UC Cooperative Extension Service, farm advisors, irrigation specialists, and State educational and research institutions to provide educational, informational, and training opportunities to growers, water supplier staff, and others on the variety of available water and irrigation management practices, operations, and maintenance techniques.
27. Increase State partnership with other entities. The State should explore and identify innovative technologies and techniques to improve water use efficiency and develop new water use efficiency measures based on the new information. Consider fast-track pilot projects, demonstrations, and model programs exploring state-of-the-art water saving technologies and procedures, and publicize the results widely. Foster closer partnership among growers, water suppliers, irrigation professionals, and manufacturers who play an important role in research, development, manufacturing, distribution, and dissemination of new and innovative irrigation technologies and management practices.
28. Initiate State collaboration with county governments to offer tax credits for installation of more efficient irrigation systems.
29. Incorporate a comprehensive educational, informational, and awareness element regarding sustainability of consumption of local products in the water use efficiency programs for growers, water suppliers, post-harvesting processors, consumers, and others. Encourage reduction of long distance transportation of commodities and importation of commodities and thus, reduce energy use and greenhouse gas emissions.

Dry-Year Considerations

30. The Agricultural Water Management Council, in cooperation with DWR, the Department of Food and Agriculture, and others, should compile measures currently in use by growers and water suppliers to deal with water shortages and droughts and develop a comprehensive agricultural drought guidebook as a storehouse of information and procedures for drought mitigation, including new and innovative methods.
31. Review and adopt standard water use efficiency approaches to meet water needs during dry years. New approaches should be explored such as alfalfa summer dry-down and regulated deficit irrigation to cope with water shortages.
32. Drought water management should be fully incorporated in agricultural water management plans.

Department of Water Resources' Near-Term Core Programs

A. Develop grant and loan criteria to determine agricultural water suppliers' eligibility for loans and grants. CWC Section10608.56 declares that on and after July 1, 2013, and agricultural water supplier is not eligible for a water grant or loan awarded or administered by the State unless the supplier complies with the requirements of SB X7-7, Part 2.55 Sustainable Water Use and Demand Reduction.

B. Continue the development of a single standardized water use reporting form, in consultation with the State Water Board, the Department of Food and Agriculture, State Department of Public Health, and Public Utility Commission. The form is to be used by agricultural water suppliers for reporting water use data and information.

C. Continue the development of an on-line submittal portal for water suppliers to use in reporting water use data, EWMPs, and AWMPs.

D. Promote, in consultation with the State Water Board, implementation of regional water resource management practices through increased incentives and removal of barriers consistent with State and federal law. Potential changes may include:
1) revisions to the requirements of integrated water management plans; 2) revisions to the eligibility for State water management grants and loans; 3) increased funding for research, feasibility studies, and project construction; and 4) expanding technical and educational support for local land use and water management agencies.

E. Make all submitted agricultural water management plans available for public inspection on DWR's Web site.

F. Prepare and submit to the Legislature reports summarizing the status of the Agricultural Water Management Plans and adoption by the agricultural water suppliers. These reports shall be prepared on or before December 2013 and in years ending with six and years ending with one.

G. Prepare reports and provide data for any legislative hearing designed to consider the effectiveness of plans.

Agricultural Water Use Efficiency in the Water Plan

[This is a new heading for Update 2013. If necessary, this section will discuss the ways the resource management strategy is treated in this chapter, in the regional reports and in the sustainability indicators. If the three mentions aren't consistent, the reason for the conflict will be discussed (i.e., the regional reports are emphasizing a different aspect of the strategy). If the three mentions are consistent with each other (or if the strategy isn't discussed in the rest of Update 2013), there is no need for this section to appear.]

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Additional References

Personal Communications

Table 2-1 Trends in Irrigation Method Area (in Million Acres)

Irrigation method	1991		2001		2010		Change from 1991 to 2010	
	Area (MA)	% of total	Area (MA)	% of total	Area (MA)	% of total	Percent change in acreage and reduction/increase of area in million acres	
Gravity (furrow, flood)	5.54	67	4.04	50	3.53	43	-36%	-2.01 MA
Sprinkler	1.43	17	1.28	16	1.24	15	-13%	-0.19 MA
Drip/micro	1.26	15	2.69	33	3.12	39	+150%	+1.86 MA
Subsurface	0.05	1	0.15	2	0.24	3	+380%	+0.19 MA
Total	**8.28**	**100**	**8.16**	**100**	**8.13**	**100**	**2.01MA reduction in gravity systems 1.86 MA increase in pressurized systems**	

Source: DWR

Note: MA = million acres.

Figure 2-1 Acres of Irrigated Agricultural Land by Irrigation method in California in 2010

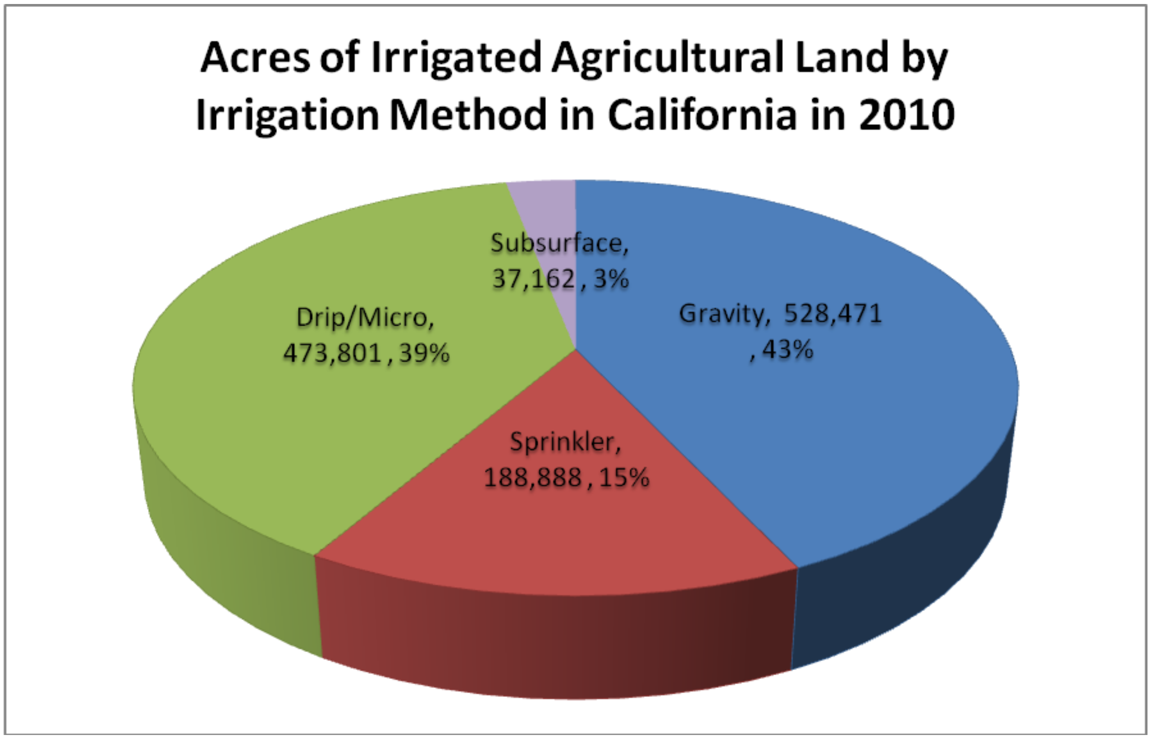


Figure 2-2 **Change in Irrigation Methods in California (1977-2010)**

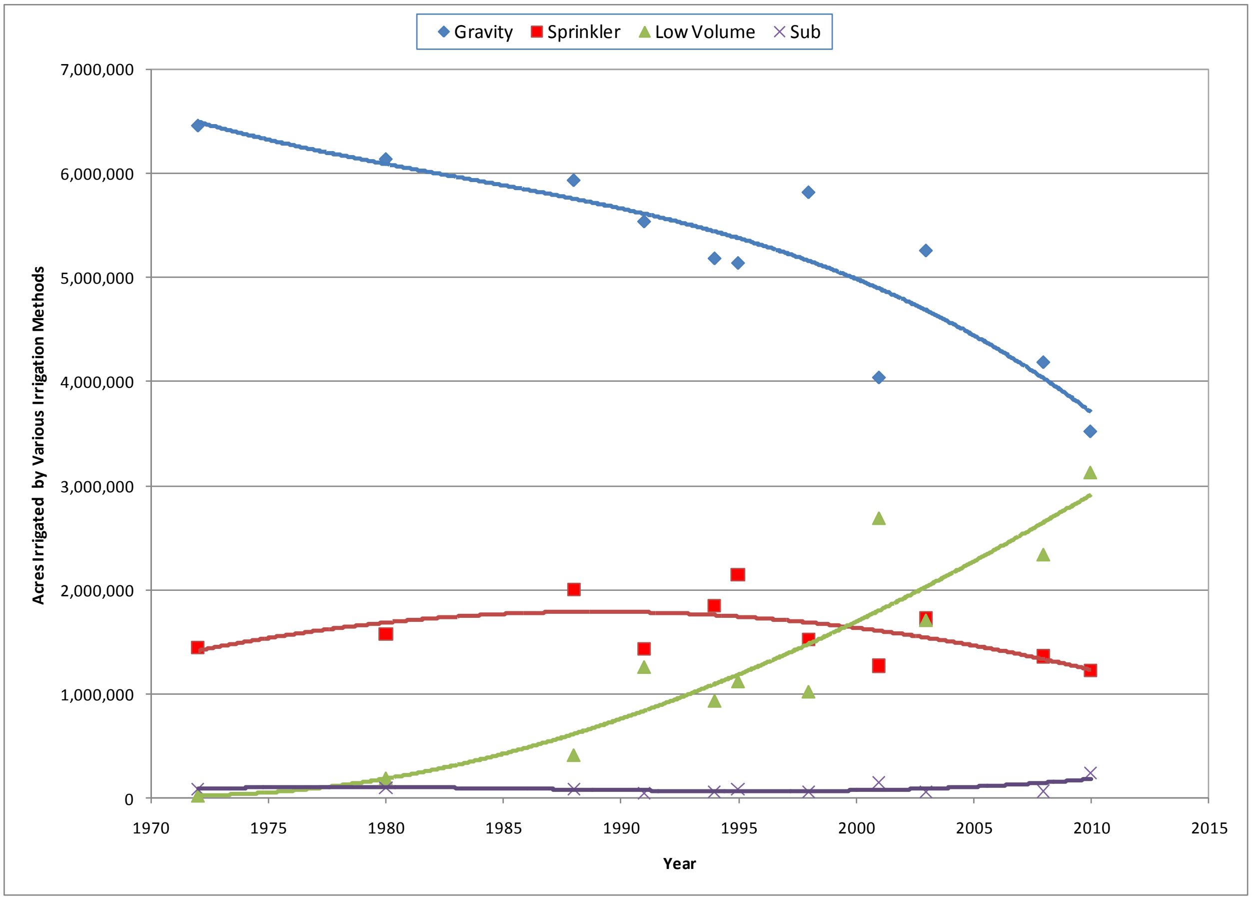


Figure 2-3 Statewide Trends in Irrigation Method Area from 1991 to 2011

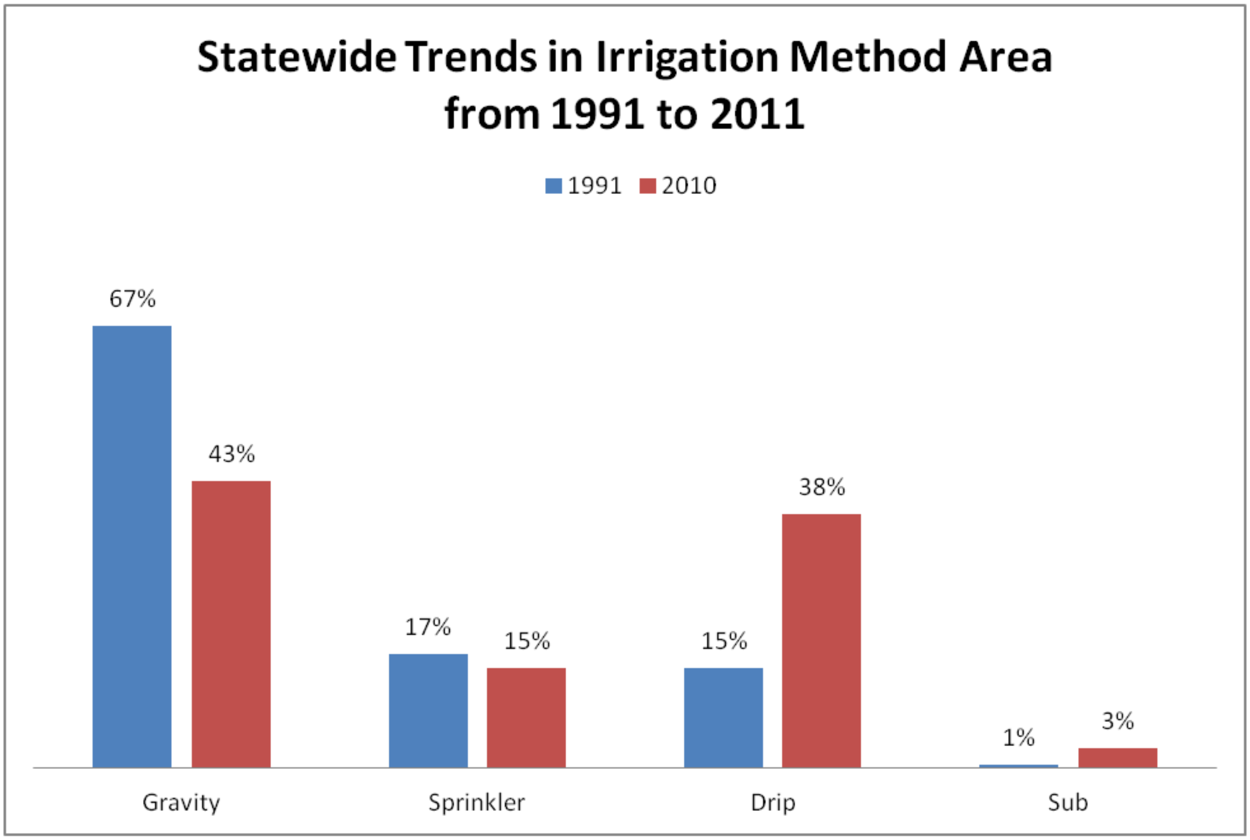
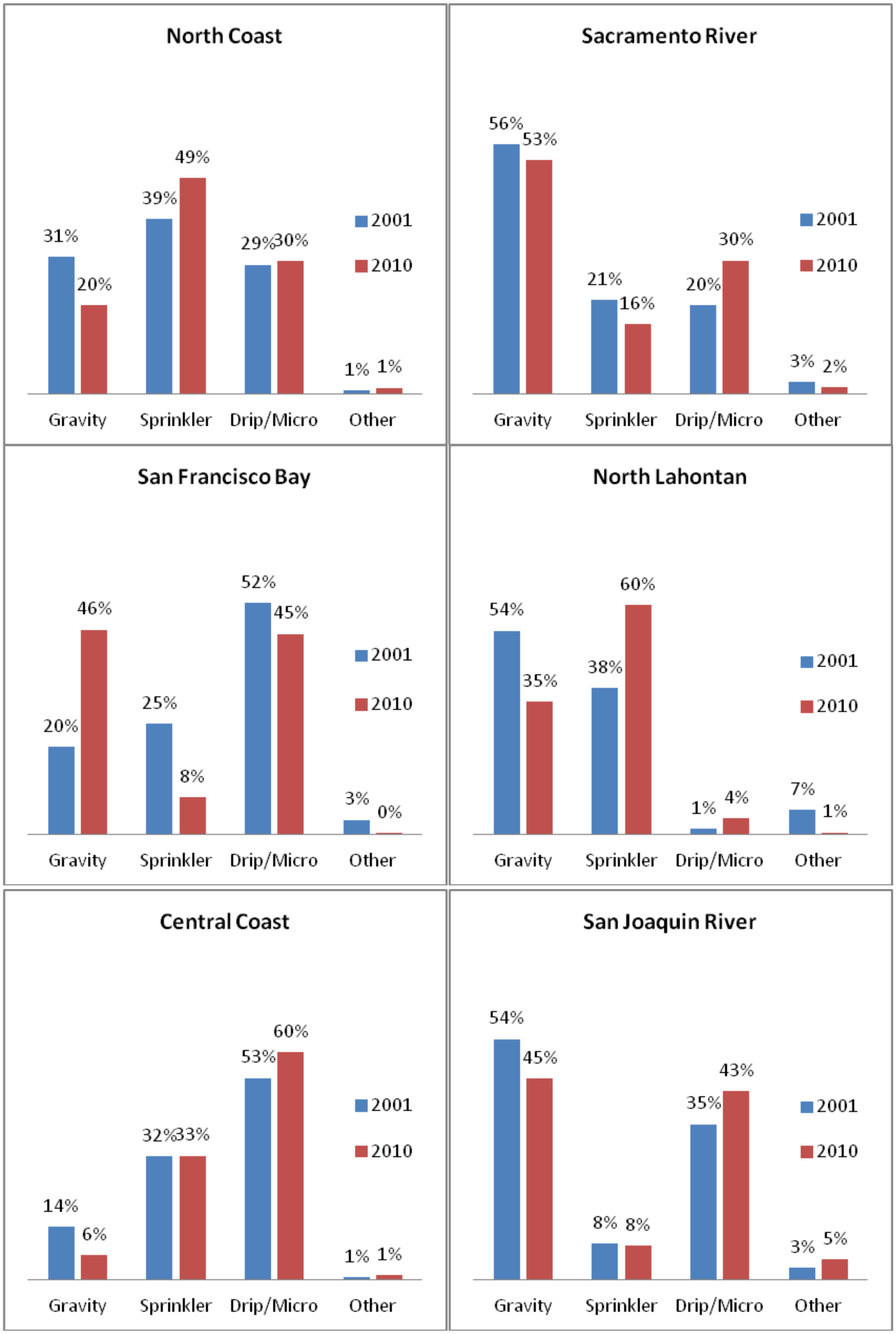
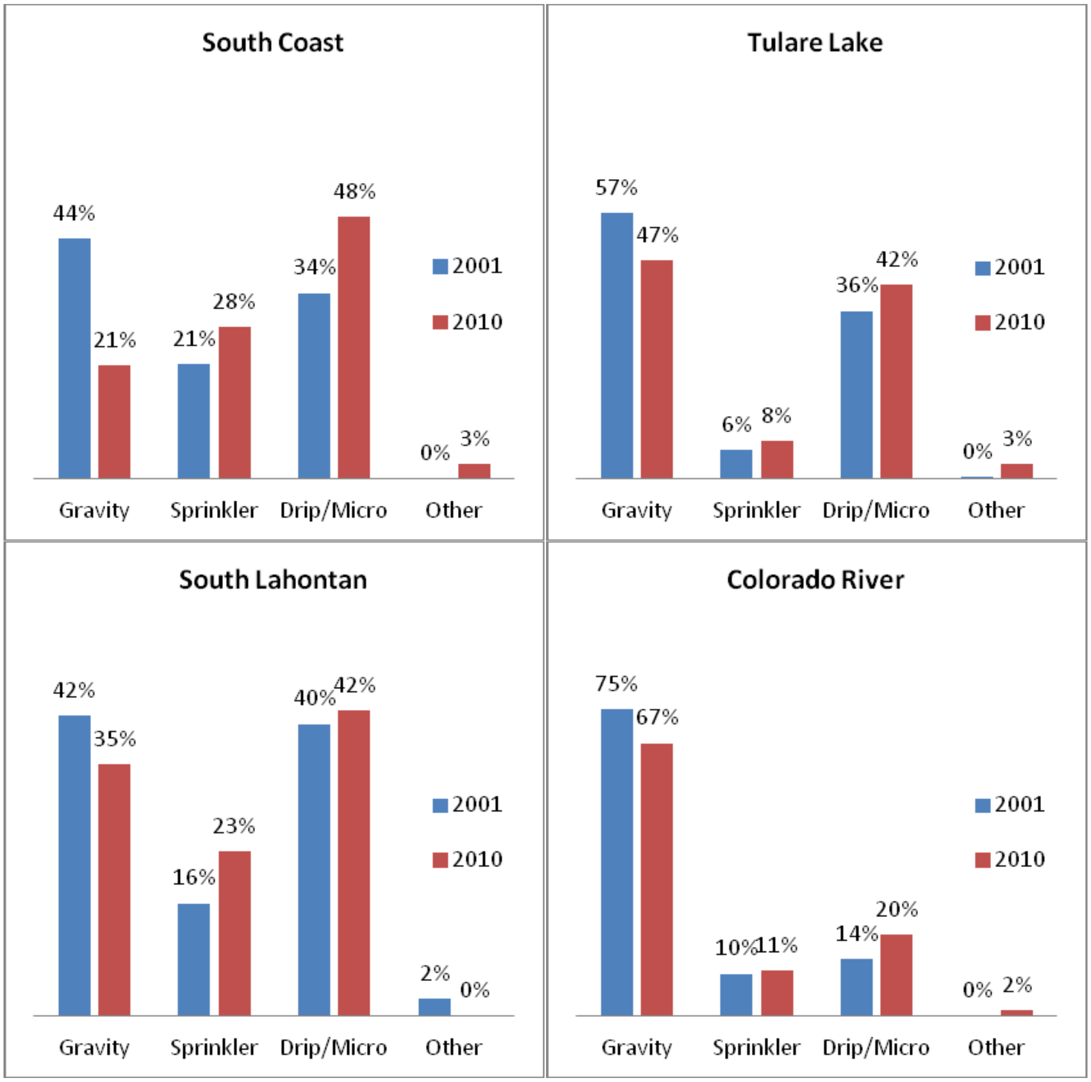


Figure 2-4 Regional Trends in Irrigation Method Areas





[Note: These charts on the regional trends in irrigation method areas will be superimposed on the State's Hydrologic Regions Map.]